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Increased Photon Emissions from the Right But Not the Left Hemisphere While Imagining White Light in the Dark: The Potential Connection Between Consciousness and Cerebral Light

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ABSTRACT

Measurements by a photomultiplier tube at distances of 15 cm from the head demonstrated significant increases in biophoton energies along the right side but not the left when subjects imagined white light in a dark environment. The increased power density of $\sim 3 \times 10^{-11} \text{ W/m}^2$ did not occur when the same subjects thought about mundane experiences. The calculated increased photon energy while imagining white light was equivalent to the involvement of action potentials from about 10^7 cerebral cortical neurons. These values are consistent with the typical numbers of neurons involved with imaginative states as inferred from fMRI technologies and the hypothesized origins of biophotons from lipid and redox reactions within cell membranes. We suggest these results support Bókkon's hypothesis that specific visual imagery is strongly correlated with the release of biophotons and may be the actual experience of organized matrices of photons. The cognitive coupling with photon emissions would also support the electron spin-mediated hypothesis of Hu and Wu for the origin of consciousness.

Key Words: biophotons, Bókkon biophoton hypothesis, cerebral hemispheres, imagination, human brain, quantitative EEG (QEEG) visualization.

1. Introduction

All living tissues exhibit a narrow band of very weak photon emission (Popp, 1988, Van Wijk and Schamhart, 1988). The dominant frequencies of these biophotons occur within the near ultraviolet to the near infrared range (Popp 1979). In the order of 100 photons are emitted per cm^2 per s (10^6 photons/ $\text{m}^2 \cdot \text{s}$) from surface boundaries such as the skin as reported by both Van Wijk et al (2006) and Cohen and Popp (1997). They employed photomultiplier tubes (PMTs) with sensitivities in the 200 to 800 nm range. Assuming an average wavelength of 500 nm ($6 \times 10^{14} \text{ Hz}$, with a velocity=c), the energy per photon would be $4 \times 10^{-19} \text{ J}$ for a sum of about $4 \times 10^{-13} \text{ W/m}^2$. For comparison the densities for cosmic rays near the earth's surface are in the order of 10^{-13} W/m^2 which is within the same order of magnitude as that produced from natural radioactive isotopes from the ground and atmosphere (Koenig et al, 1981). In the following experiment we measured and explored photon

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emissions from the cerebrum during reversible cognitive sequences while dark-adapted normal subjects sitting in the dark imagined white light or engaged in casual ideation.

There has been evidence that very photon-active volumes of matter, such as the human brain (Dotta et al, 2011a), may generate higher densities of photons coupled to cognitive activity. For example, the energy associated with action potentials from neurons can be described as the product of 1.2×10^{-1} V (the net change of 120 mV) and the unit charge of 1.6×10^{-19} A·s, that is, 2×10^{-20} J (Persinger, 2010). The wavelength equivalence is 10 μ m, the approximate width of a neuronal soma. In addition, if visible biophotons around (for example) 500 nm wavelengths were frequency (or phase) modulated through intrinsic processes whose net change was $\sim 10^{-20}$ J, the shift would only require ~ 10 nm, the width of a plasma cell membrane. That membrane-relevant information might be mediated by photons becomes even more salient when one considers quantitative values. The times required for a photon moving at the velocity of light to traverse the width (~ 10 nm) of a plasma cell membrane and for an electron (Bohr magneton) to complete one (unit) orbit are both in the order of 10^{-16} s.

The convergence of the values between the times required for a photon to traverse a neuronal membrane and for a single electron orbit would be congruent with the conditions to produce or reflect entanglement. As suggested by Hu and Wu (2006) quantum entanglement originated from the primordial spin processes in non-spatial and non-temporal pre-space time. Consequently the fundamental parameters constrained by this condition affect the physical and chemical reactions and properties in all forms of matter. Living systems are composed of matter. Electrons become entangled through the spin process by exchanging one or more entangling photons.

Power densities of biochemiluminescence from brain tissue (Dotta et al, 2011a) and hippocampal slices have been measured in the order of 10^{-13} to 10^{-12} W/m² (Isojima et al, 1995; Kobayashi et al, 1999). The hippocampal emissions were not spurious and were phase-locked to intrinsic theta activity (Sun et al, 2010). In humans there is evidence that intracerebral changes in biophoton activity are related to consciousness and phosphene phenomena (Sun et al, 2010, Bókkon, 2005; 2009).

In his original and imaginative articles Bókkon (2005; 2009) suggested that biophotons mediate information within brain space during dreams (in particular) and wakefulness. In fact intracerebral biophotons were proposed to generate pictures during thinking. Subsequent calculations and integration of the literature suggested that retinotopic electrical signals could be converted into synchronized bioluminescent photons by cellular redox and reactions of free radicals within cell membranes to produce intrinsic biophysical pictures during visual perception and imagery (Bokkon and D'Angiulli, 2009; Bokkon et al, 2011). Recently Wang et al (2011) tested Bókkon's theory and was the first to demonstrate spontaneous and visible light-induced photon emission from rat eyes.

Bókkon's theory is compatible with Wu and Hu's (2006) hypothesis that unpaired electron spin networks are the "mind screen". In their model the neural plasma membranes and intrinsic proteins represent the interface between the mind screen and memory matrices. When the diffusing dynamics associated with nitric oxide (NO) and oxygen (O₂) are viewed as pixel-activating agents,

the triad of processes form the neural substrate of consciousness. Thus, quantitative measurements, rational calculations, and carefully constructed theories predict strong correlations and perhaps *an identity* between human thinking and photon emissions from the same cerebral volume.

While investigating the photon emissions by PMT from cultures (about 10^6 cells) of mouse melanoma cells that were “stressed” at room temperature (20°C) in the dark during the 12 hr after removal from incubation we observed distinct periods of increase in energy emission in the order of 10^{-11} W/m² (Dotta et al, 2011b). This was equivalent to 10^{-14} J over the width of the culture dish (and PMT aperture) or about 10^{-20} J/s per cell. The conspicuous effects were in sharp contrast to cell cultures maintained at 37°C where applied energies are often required to evoke discernable biophoton emissions. Biochemical treatments to test the involvement of several molecular pathways strongly implicated the plasma membrane as the source (Dotta et al, 2011b).

Given the sensitivity of our instrumentation to measure the likely plasma membrane-related changes in energy emission from cells we decided to measure the photon emission from the sides of the heads of normal volunteers. We (Hunter et al, 2010) had reliably measured obvious increases of photon emission in the order of 10^{-11} J/s at about 15 cm from the right temporoparietal region of Sean Harribance, a person known for exceptional intuition about peoples’ memories when they were near him as well as for inhibiting cancer cell growth. When engaging in these activities Harribance reported that he concentrated on “cerebrally-generated white light” during a specific cognitive state that was associated with not only a specific configuration of quantitative electroencephalographic activity but measureable emissions of photons from the right but not the left side of his brain at the level of the temporoparietal lobes.

2. Methods and Materials

A total of 16 men and women between the ages of 20 and 30 years of age volunteered as subjects. Photon emissions from the right and left sides of each subject's head were measured with a Model 15 Photometer from SRI Instruments (Pacific Photometric Instruments) with a photomultiplier tube (PMT) housing (BCA IP21) for a RCA electron tube (no filters). The tube was positioned in counterbalanced order approximately 15 cm from the left or right side of the subject's head at the level of the temporal lobes. This distance was selected based upon our pilot study with Sean Harribance as well as for convenience and to minimize any potential subtle contributions from simple heating. The PMT was covered with about 5 cm of cloth to obtain optimal sensitivity as defined by no change in slope over increments of 10 min.

Calibration for photon emission had been completed by comparing the unit response directly to a digital luxmeter at higher intensities (> 1 lux) and by measuring the response to a LED at 10 mA (5 millicandella; 2 millilumens/45 degree) at various distances for intensities much less than 1 lux. Lux was transformed to Watts/m². Calibration indicated that a change of 1 unit at the maximum sensitivity of 1500 with an input current of 0.01 (.001 max) in order to obtain measures within the medium range of the 0 to 100 unit meter was equivalent to 5×10^{-11} W/m². At this PMT setting the “background photon ‘noise’” for the meter was mid-range (about 45 units); higher sensitivity (.003)

exceeded 100 units and displayed a saturated response. The output was transformed to mV (millivolt meter) and sent to an IBM ThinkPad laptop (Windows 95) in another room where samples were taken three times per second (the limit of the laptop software) during the experimental period.

The essential procedure was an a,b design repeated three times while the measurements were taken from either the left or the right side of the head. After dark adaptation for about 15 min each blindfolded subject was told to relax, think of white light all around him or her and to focus light into the PMT, relax, focus, relax, and then focus. The duration of each component (relaxation or "imagining white light") ranged between 45 and 90 sec but was the same for each subject. The biophoton emissions (from 135 to 270 measures from the 3 samples/s) were averaged for each of the six (3 thinking about light, 3 not thinking) intervals.

To discern if there were differential hemispheric power densities of light emissions, photon emissions were measured by the PMT from the left or right side of each subject's head at the level of the temporoparietal lobes. For half the numbers of subjects the left hemisphere was measured first while for the other half of the numbers of subjects the right hemisphere was measured first. The measurement procedure was the same for each hemisphere. We selected "white light" as the target cognition because the results of our many pilot experiments while studying introspection and entoptic imagery suggested that *diffuse white light* for dark adapted normal people sitting blindfolded in the dark is the easiest to enhance voluntarily through imagination.

3. Results

As can be seen in Figure 1 there were statistically significant net increases [$F(1,14)=5.39$, $p < .001$; $\eta^2=.30$] in photon emissions over the right hemisphere when the subjects imagined light. The changes were *not* statistically significant over the left hemisphere. Imagining light or not imaging light explained 30% of the variance in the net increase ($M=0.51$, $SD=0.32$ units) in photon emission from the right hemisphere as compared to the left hemisphere ($M=0.15$, $SD=.26$). An increase of 1 unit, based on two methods of calibration, was equivalent to 5×10^{-11} W/m². There was no statistically significant difference in baseline photon emissions during relaxation periods between the left and right sides of the head.

For illustration, the means and standard deviations for PMT measurements during periods of not imagining and periods of imaging light for the left and right side of the head are shown for one subject in Figure 2. Post-experiment interviews verified that each subject had imagined "seeing white light" in the dark and had tried by imagination to focus the light into the PMT after the instructions and relax during the intervening periods. The "content" of those relaxation periods were later reported to be primarily thoughts about imminent classes, tests, or meeting with friends.

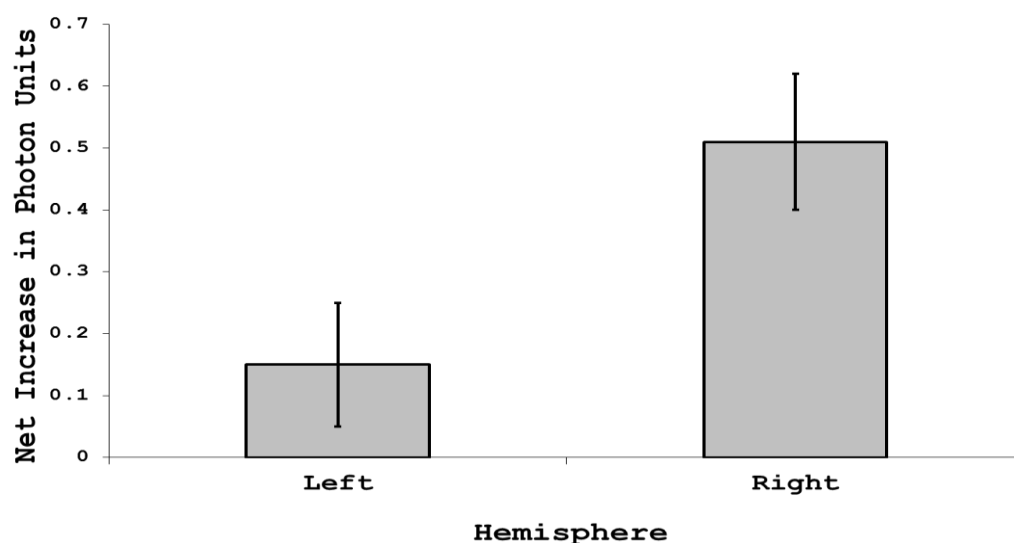


Figure 1. Means and standard errors of the mean (vertical bars) for the net change in photon energy measured by the photomultiplier tube 15 cm from the left or right side of the skull during imagining white light vs not imagining light. A change in 1 photon energy unit is equivalent to $5 \times 10^{-11} \text{ W/m}^2$.

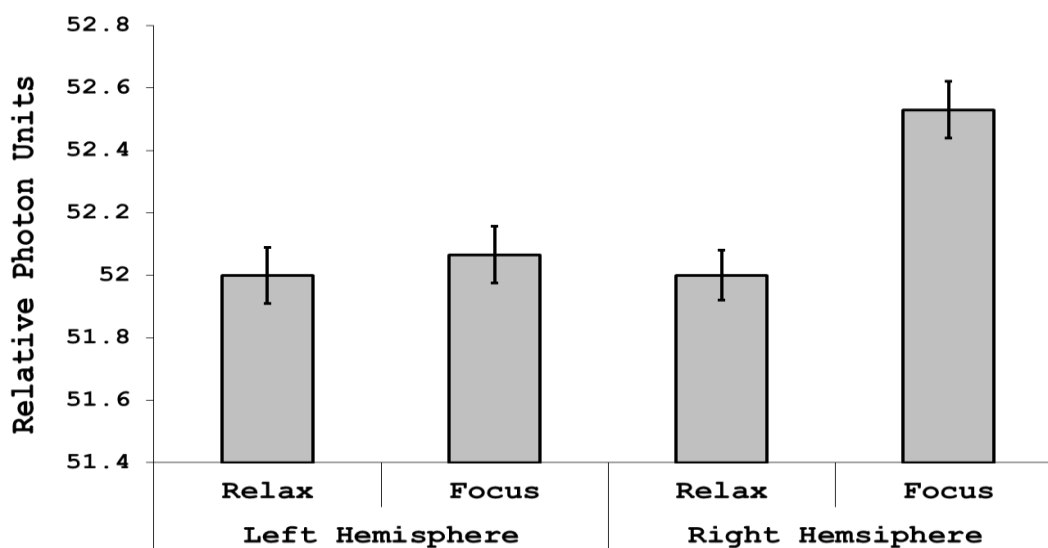


Figure 2. Means and standard errors of the mean of net changes in photon energy from the left and right side of the skull of a single subject while sitting in a dark room and either relaxing (did not think of light) or visualizing white light. Summed durations of each condition (not imagining vs imagining light) was 135 s.

4. Discussion

We selected the simple instruction to "visualize white light" to assess Bókkon's (2005; 2009; Bokkon et al, 2009, 2011) innovative concepts that when a person "generates" an image during thinking or dreaming there are *actual photons* emitted within the cerebral matrices. This subjective visual image may be the perception of actual photons. Given the recent calculations by Bókkon et al (2010) that photon intensity is higher inside of cells than without during "visual perception", we had reasoned that some extracerebral emission should occur at levels sufficient to be measured in the dark with a PMT. The magnitude of this increase in photon emission was at least 10,000 times weaker than what one would perceive looking at the stars on a clear, moonless night but about 100 times greater than the background energies from cosmic radiation.

We suggest that the right hemisphere effect is not simply because of its slightly greater blood flow (Roland and Friberg, 1985) or electroencephalographic voltage (Niedermeyer et al, 1987) for alpha activity. The magnitude for these values are only about 10% more over the right than the left hemisphere while the photon emissions were a factor of 3 (300%). The greater proportion of white matter within the right hemisphere compared to the left would also be consistent with our working hypothesis that the emissions of photons are strongly correlated with the action potentials of axons.

An average increase of 0.5 units for our system where a 1 unit increase is $5 \times 10^{-11} \text{ W/m}^2$, would be equivalent to $1.4 \times 10^{-1} \text{ m}^2$ (half the spherical surface area at 15 cm) multiplied by that value or between 3 and $6 \times 10^{-12} \text{ J/s}$. When divided by the essential quantum of $2 \times 10^{-20} \text{ J/action potential}$ (Persinger, 2010) this would be equivalent to about 10^8 action potentials. Assuming the average activity of 10 Hz per neuron, this means that an additional 10^7 (on average) neurons within the cerebral cortices were activated during the imagining of light by the subjects. These values are remarkably similar to those predicted by Bókkon et al (2010;2011) for the numbers of photons involved with the final stage of non-linear (iterative) biochemical reactions in the V1 and V2 regions of the cerebral cortices during visual imagery. The estimates are even more convergent when Bókkon et al's (2010) calculations are considered.

Given there are about 20 billion neurons per hemisphere (Blinkov and Glezer, 1968; Pakkenger and Gundersen, 1997) and each hemisphere displays a surface area of $80,000 \text{ mm}^2$, an increase of about 1% of available neurons for this imagined task would have occurred. For comparison, imagining visual images or reconstructing visual experiences during fMRI (functional magnetic resonance imaging) or PET (positron emission tomography) measurements can involve voxels with summed volumes of about 100 to 150 mm^3 (e.g., Brewer, et al, 1998). With an average of 58 neurons per 0.001 mm^3 within the cerebral cortices, the total numbers of neurons for this volume would be about 10^7 . This is the same order of magnitude that was associated with our subjects who simply imagined "white light" in the dark.

That the putative biophoton emissions were related to cerebral processes, in this case "thinking" about white light (rather than "heat" or origins from "reflected light" from the scalp or hair) is suggested by two major observations. First, the significant neurocognitive effect occurred along the right hemisphere but not the left. Second, the amount of energy emission was comparable to that

associated with the estimated numbers of neurons associated with cognitive processes and satisfies the theoretical predictions by Bókkon et al (2010) for visual imagery.

Superficially at least there appears to be discrepancies between what we assume are the essential cellular spatial dimensions and the range of measurements by the PMT. The width of a plasma cell membrane is ~ 10 nm and the width of an average neuronal soma is ~ 10 μ m while the primary range of detection for the PMT was between 400 and 800 nm. This discontinuity could be resolved if we assumed the presence of frequency or phase modulation of light during the generation of biophotons. For example the energy associated with 500 nm wavelengths is $\sim 4 \times 10^{-19}$ J which is more than a factor of 10 greater than the “quantum unit” (Persinger, 2010) of 10^{-20} J associated with both the action potential and the resting membrane potential. However if a 500 nm wavelength was frequency modulated by the width of a membrane (~ 10 nm) to 490 nm ($\sim 4.1 \times 10^{-19}$ J) the net difference in energy would be 10^{-20} J.

In other words the “carrier” frequencies would be photons within the visible range but the cellular or action potential-related patterns of information would be mediated within the frequency-modulation or phase-modulations of that “carrier band.” Traditionally the difference between the group velocity of a wave (the overall shape of the wave’s amplitudes) as it propagates through space, and the phase velocity within the wave envelope, has been considered minimal. However the recent evidence that the photon displays a non-zero mass (Tu et al, 2005) allows for the dispersion of light which produces frequency dependence in velocity. As a result, group velocity will differ from phase velocity. This would contribute to a third state of polarization in which the vector of the electric field is along the line of motion, the “longitudinal photon”.

Digital sequences, which define information generated from a single neuron, could be carried within a single phase or frequency shift that would be potentially facilitated by the “longitudinal” photon. The conspicuous congruence between the time ($\sim 10^{-18}$ s) required for a photon moving at c to traverse the plasma cell membrane and the time required for the single rotation of an electron (or the time required to move to another atom) indicates that light emission/absorption and the single orbital time of an electron within the matter that composes membranes may be more interactive than previously assumed. That visual images may be organized as fields of biophotons as conceptualized by Bókkon requires a re-evaluation of traditional approaches to the relationship between brain activity and cognitive processes.

The generation of photons by cognition, particularly imagination, may have profound theoretical and philosophical implications for theories of consciousness. Thought-coupled patterns of photon emission increase the importance and perhaps practical application of quantum entanglement. If Wu and Hu’s (2006) primordial spin process is considered and consciousness resides within the domain of unpaired nuclear and/or electron spins and entangled photons which constitute the “minds pixels”, then a non-local nature of at least a subset of consciousness might occur. Pre-space-time would be a holistic domain located outside of space-time but connected through quantum channels to everywhere in space time (Wu and Hu, 2006). Although apparently conceptual, the quantitative solution for the total volume of an electron and “quantum thread” with Planck’s length

as its radius are congruent. With an estimated volume of an electron around 10^{-44} m^3 a cylinder with a radius of $1.6 \times 10^{-35} \text{ m}$ (Planck's length) would have a cross sectional area of $8 \times 10^{-70} \text{ m}^2$. For this "thread" to have the equivalent volume of an electron its length must be 10^{26} m , or effectively the width of the universe.

Such a "holographic-like" quality to the electron and proton could accommodate the calculations by Persinger and Koren (2007). They showed that the time required for one Planck's length to expand one Planck's length required the age of the universe. On the other hand the time required for the width of the universe to expand one Planck's length was Planck's time, about 10^{-44} s . The necessary convergence between these two boundary conditions (Koren and Persinger, 2010), like Wu's and Hu's (2006) model, does not contradict classical relativity because the latter's framework involves physical events occurring within space-time.

There is also a potential application to the relationship between the electromagnetic quantum associated with light and gravitational phenomena (Persinger, 2012). If we assume the upper limit for the rest mass of the photon is $\sim 10^{-52} \text{ kg}$ and Planck's length (10^{-35} m) is the minimal distance then the intrinsic (unit) of gravitational attraction would be $[(10^{104} \text{ kg}^2/10^{-70} \text{ m}^2) \cdot 6.67 \times 10^{11} \text{ m}^3/\text{kg s}^2]$, or, between 10^{-45} and 10^{-44} N . If this force were extended over the width of the visible universe of about 10^{26} m , the central tendency for the energy would be 10^{-19} to 10^{-18} J . This energy divided by Planck's constant is between 10^{14} Hz and 10^{15} Hz or within the order of magnitude of the band of the visible spectrum, i.e., light.

Although the gravitational forces are very small they are comparable to those associated with the distance between the potassium ions that maintain the resting membrane potential of the plasma membrane of the neuron. The average distance between these ions within the $\sim 0.6 \text{ nm}$ layer of the approximately million charges over the surface of the membrane is about 10 nm (Persinger, 2010). The energy associated with electric forces of 10^{-12} N between any two equally spaced charges when applied over the width (10^{-8} m) of the membrane is about 10^{-20} J . With typical oscillations in the order of 10 Hz , the energy per second would be about 10^{-19} J .

On the other hand the gravitational force between the mass of two potassium atoms separated by about 10 nm is $\sim 10^{-45} \text{ N}$, the same magnitude as the forces that would exist between two photon rest masses separated by Planck's length. Consequently the gravitational force between two potassium ions on a plasma membrane surface spread over the width of the universe (10^{26} m) would also result in energies of about 10^{-20} J .

The different velocities associated with different frequencies (Tu et al, 2005) that result from a discrete mass for the photon have significant implications for the specious present, the duration of time that is considered "now". When applied to the Lorentz equation the dilatation of time can range from a few minutes to several tens of years, depending upon the frequency of the photon. For visible wavelength frequencies, such as the band recorded in the present studies, the widening would be in the order of 3 days or less. However if higher frequency photons were emitted with specific types of cerebral activity coupled to consciousness, the widening could involve more than a decade (Dotta and Persinger, 2009). It may be relevant that the difference in energy equivalences of

the masses associated with relativistic compression of the length of an electron between its classical radius and Compton's radius (2.4×10^{-12} m) is approximately 10^{-20} J, the value for the neuronal quantum associated with the action potential (Persinger et al, 2008).

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